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The validation of computer simulations of rigid lens fluorescein patterns

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Abstract

This study is designed to validate a computer simulation of rigid tens fluorescein patterns by comparing actual photographs of rigid gas permeable (RGP) lens fits to the computer simulation. The simulated graphic is derived from calculating tear layer thicknesses for a given lens/cornea combination, and plotting using a variable green gradient. It is anticipated that this computer simulation could be a valuable adjunct to teaching RGP fitting principles. It was determined that observers indicated no significant difference in the evaluation of steep, flat and aligned fits of actual photographs to those of the simulations using an alpha value of .05. However, a significance in favor of the simulations being correct can be noted within the .10 alpha level.

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The Validation of Computer Simulations of Rigid Lens Fluorescein Patterns

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About The Author

Darek Huggett, graduated from Pacific University in 1989 with a Bachelor of Science degee with a major in Visual Science. He is a active member of the Student Optometric Association.He is currently a fourth year optometry student at Pacific University College of Optometry in Forest Grove Oregon and will be graduating with a Doctorate of Optometry in May of 1993.

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ABSTRACT

This study is designed to validate a computer simulation of rigid lens fluorescein patterns by comparing actual photographs of rigid gas permeable (RGP) lens fits to the computer simulation. The simulated graphic is derived from calculating tear layer thicknesses for a given lens/cornea combination, and plotting using a variable green gradient. It is anticipated that this computer simulation could be a valuable adjunct to teaching RGP fitting principles. It was determined that observers indicated no significant difference in the evaluation of steep, flat and aligned fits of actual photographs to those of the simulations using an alpha value of .05. However, a significance in favor of the simulations being correct can be noted within the .10 alpha level.

INTRODUCTION

Many of the new practitioners now resist the fitting of rigid gas permeable (RGP) contact lenses due to the lack of experience and knowledge. The fitting of RGP's has often been called an art for the main reason that many judgments on lens design and fit take a considerable amount of experience on the part of the practitioner to avoid any wearing problems the patient may experience. [4] Obrig's accidental discovery of the value of fluorescein in 1938 proved to be a mile stone in developing a more scientific approach in fitting contact lenses.[6] Areas of corneal clearance and touch were once determined through a transparent lens. With the use of fluorescein a two dimensional representation of a complex-3 dimensional shape simplified the evaluating process. Areas between the lens and cornea are assessed by fluoresceins ability to fluoress indicating tear layer thickness. Areas of little to no tear layer do not fluoress and are seen as dark blue. Those areas having a mid to heavy tear layer are seen as dark green, light green and yellow in appearance respectively, thus creating a contour pattern. [1] Reading these contour of fluorescein patterns is important since there is no universally accepted specification for the many RGP parameters available. [1] At this time flatter and larger fits are emphasized with RGP fitting due to flexure of the gas permeable materials. [5] It has also been determined that an optimal fit will show central alignment or just a trace of fluorescein roughly, .025mm, indicating minimal central clearance. [2,6] The peripheral curve of the lens is expected to be sufficiently deep and wide enough to avoid any mechanical irritation. The amount of tear layer in this region has been determined to be roughly .08mm.[2] A significant obstacle seen by evaluators is that a patients corneal shape is aspheric and often in more than one meridian.[4] The proper elliptical corneal contour of a patient needs proper instrumentation to measure its' slope. Being that this instrumentation is impractical in many offices a fluorescein pattern evaluation becomes the method of choice.[4] Often a series of lenses with various dimensions are tested on the patient's eyes in a trial and error fashion in an attempt to arrive at the best fit. This is done because our patients' total corneal shape, lid position, tension and action of blinking are often unpredictable.[4] Students as well as practitioners have often used nomograms and fluorescein slides to assist in their learning process.[3] By the use of a computerized simulated fluorescein graphic, optometry students may begin to obtain the art of RGP fitting in a more scientific and orderly fashion. As practitioners, they may find its use helpful to expedite the fitting process of difficult, overly sensitive patients. This study assessed the validity of this type of computer program by determining any differences in the ability to distinguish steep, flat, and aligned fits between actual and simulated fluorescein patterns as well as being able to match the two corresponding fits.

METHODS

All potential subjects under went an initial comprehensive optometric examination prior to consideration for the study. Eligible subjects were to be free of ocular systemic disease which could contraindicate contact lens wear and be suited to RGP lens wear. Five suitable subjects were fit in one eye with a series of five Fluorex 700 RGP lenses with varying parameters ranging from two diopters flat to two diopters steep. This was done by accepted clinical procedures for the fitting and management of contact lens patients. Each patients central corneal curvature was determined by a Humphery Auto keratometer. After each fit, the patient was photographed using a standard Macro camera adapted for fluorescein photography fig. (B). Each slide had a comparative simulated graphic derived by the computer from calculating tear layer thickness for a given lens/cornea combination and plotting using a variable green gradient. Parameters entered into the Fluropredicter program include the: base curve and peripheral curves in millimeters of the lens; the widths of the optical zone and peripheral curves in millimeters; and the radius in millimeters with axis of each meridian. Each cornea was presumed to have a .8 P value indicating the average individuals elliptical contour and a eccentricity of .55.[2] This was also figured into each simulation. The computer derived simulation was then video taped and photographed off a TV monitor fig. (A).

Upon the collection of data, two groups of observers were solicited for validation. The first group consisted of Pacific University staff Optometrists with at least ten years of clinical experience. The second group contained optometry students with little to no experience. Each patients' slides were observed individually in a single blind study and determined to have either a steep, flat or aligned fit. The assessment was based on central, apical, mid peripheral and edge fluorescein patterns. Computer simulations of each photo developed by the Fluropredicter program were also assessed in this fashion. After evaluating the slides and simulated pattern of each patient, each observer then matched to the best of their ability, each slide to the corresponding simulation. The accuracy of fittings and the ability to match slides to simulations was assessed as well as any differences which may have existed between the two observation groups.

Data

Fluorex 700 specifications

Diameter	Curve Widths (1/2/PC)	Optical Zone
Below 8.0	.1+ / .1+ / .3	= OAD. - 1.2 mm
8.0 - 8.6	.2 / .1+ / .3	= OAD. - 1.3 mm
8.7 - 9.2	.2 / .2 / .3	= OAD. - 1.4 mm
9.3 - 9.6	.2 / .2 / .3+	= OAD. - 1.5 mm

Patient #1

K'S 7.95 @168 8.04 @78

LENSES

#	BC	POWER	DIAM.	CT	OZ	1	2	3
1	7.80	-2.00	8.8	.17	7.3	8.8	10	12
2	7.90	-2.00	8.8	.17	7.3	9.0	10.5	12
3	8.00	-2.00	8.8	.17	7.3	9.0	10.5	12.5
4	8.25	-2.00	8.8	.17	7.3	9.0	10.5	12.5
5	8.10	-2.00	8.8	.17	7.3	9.2	10.5	12.5

Patient #2

K'S 7.70 @07 7.53 @97

LENSES

#	BC	POWER	DIAM.	CT	OZ	1	2	3
1	7.70	-2.00	8.8	.17	7.3	8.8	10	11.5
2	7.65	-2.00	8.8	.17	7.3	8.8	10	11.5
3	7.55	-2.00	8.8	.17	7.3	8.6	10	11.5
4	7.80	-2.00	8.8	.17	7.3	8.8	10	12
5	7.88	-2.00	8.8	.17	7.3	9.0	10.5	12

Patient #3

K'S 7.99 @39 7.87 @129

LENSES

#	BC	POWER	DIAM.	CT	OZ	1	2	3
1	8.10	-2.00	8.8	.17	7.3	9.2	10.5	12.5
2	7.90	-2.00	8.8	.17	7.3	9.0	10.5	12
3	8.00	-2.00	8.8	.17	7.3	9.0	10.5	12.5
4	7.80	-2.00	9.5	.17	7.9	8.8	10	12
5	8.18	-2.00	8.8	.17	7.3	9.2	10.5	12.5

Patient #4

K'S 7.91 @10 7.78 @100

LENSES

#	BC	POWER	DIAM.	CT	OZ	1	2	3
1	7.90	-2.00	9.2	.17	7.6	9.0	10.5	12
2	7.80	-2.00	8.8	.17	7.3	8.8	10	12
3	7.70	-2.00	9.5	.17	7.9	8.8	10	11.5
4	8.00	-2.00	8.8	.16	7.3	9.0	10.5	12
5	8.10	-2.00	8.8	.17	7.3	9.2	10.5	12

Patient #5

K'S 7.74 @18 7.76 @108

LENSES

#	BC	POWER	DIAM.	CT	OZ	1	2	3
1	7.95	-2.00	9.5	.17	7.9	9.0	10.5	12
2	7.65	-2.00	9.5	.18	7.9	8.8	10	11.5
3	7.55	-2.00	8.8	.18	7.3	8.6	10	11.5
4	8.15	-2.00	8.8	.15	7.3	9.2	10.5	12.5
5	7.75	-2.00	8.8	.17	7.3	8.8	10	11.5

Figure A

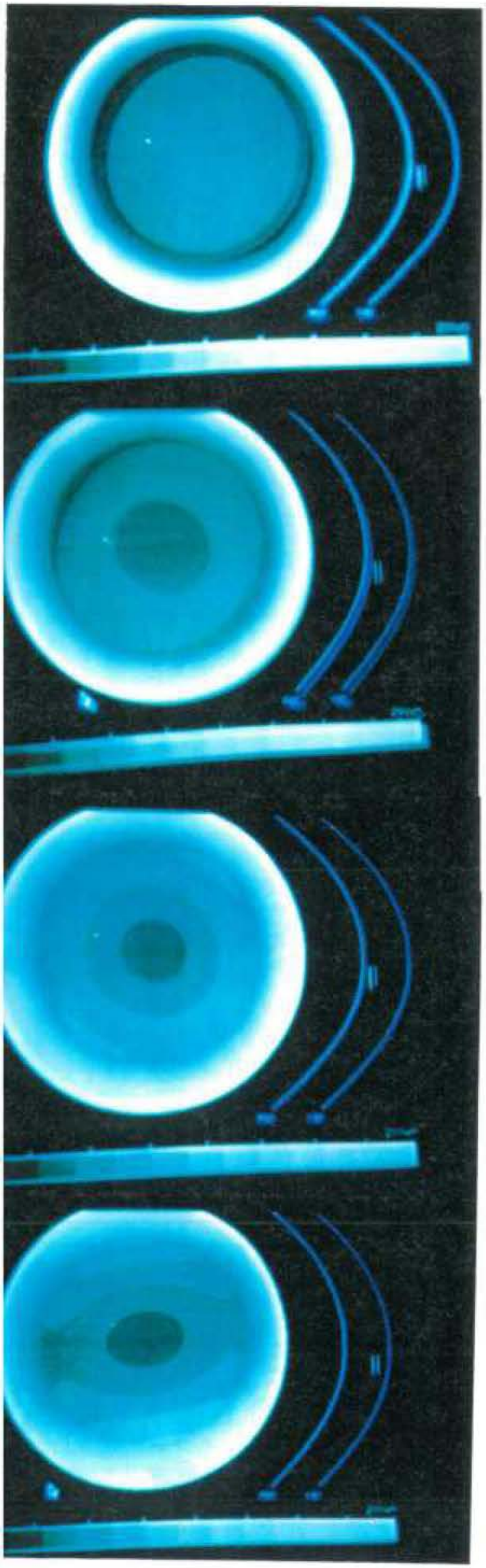
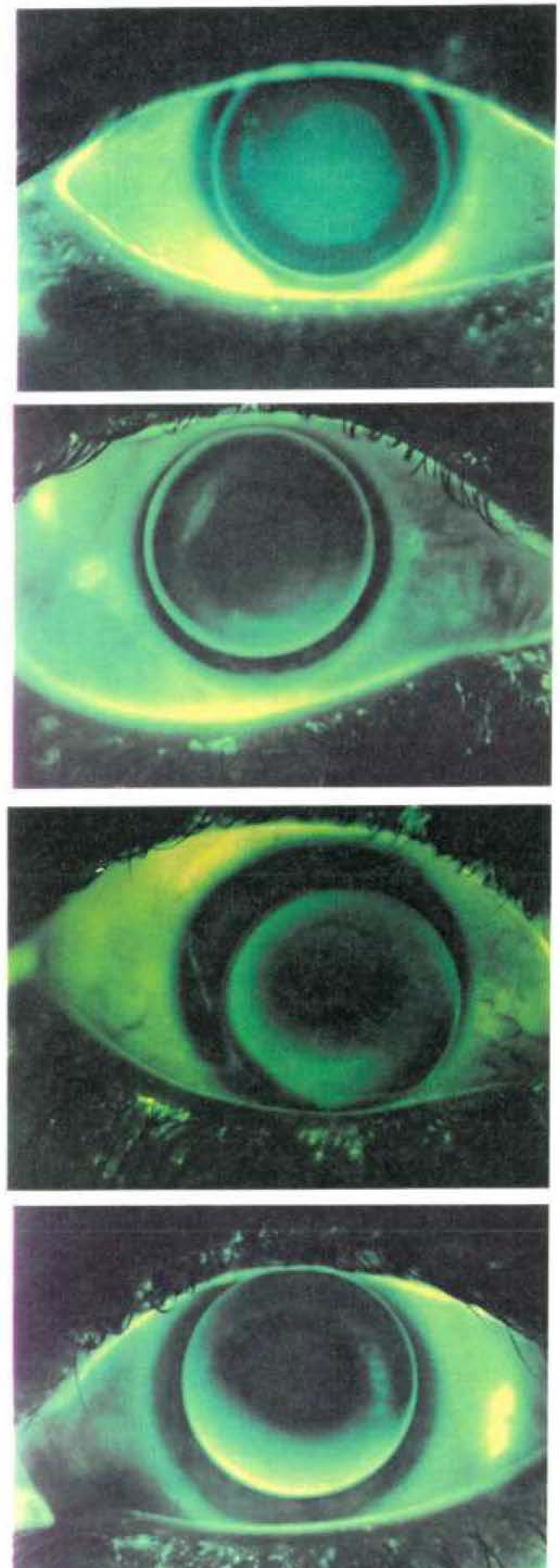


Figure B



7.74 @18
7.76@108
.50 D STK

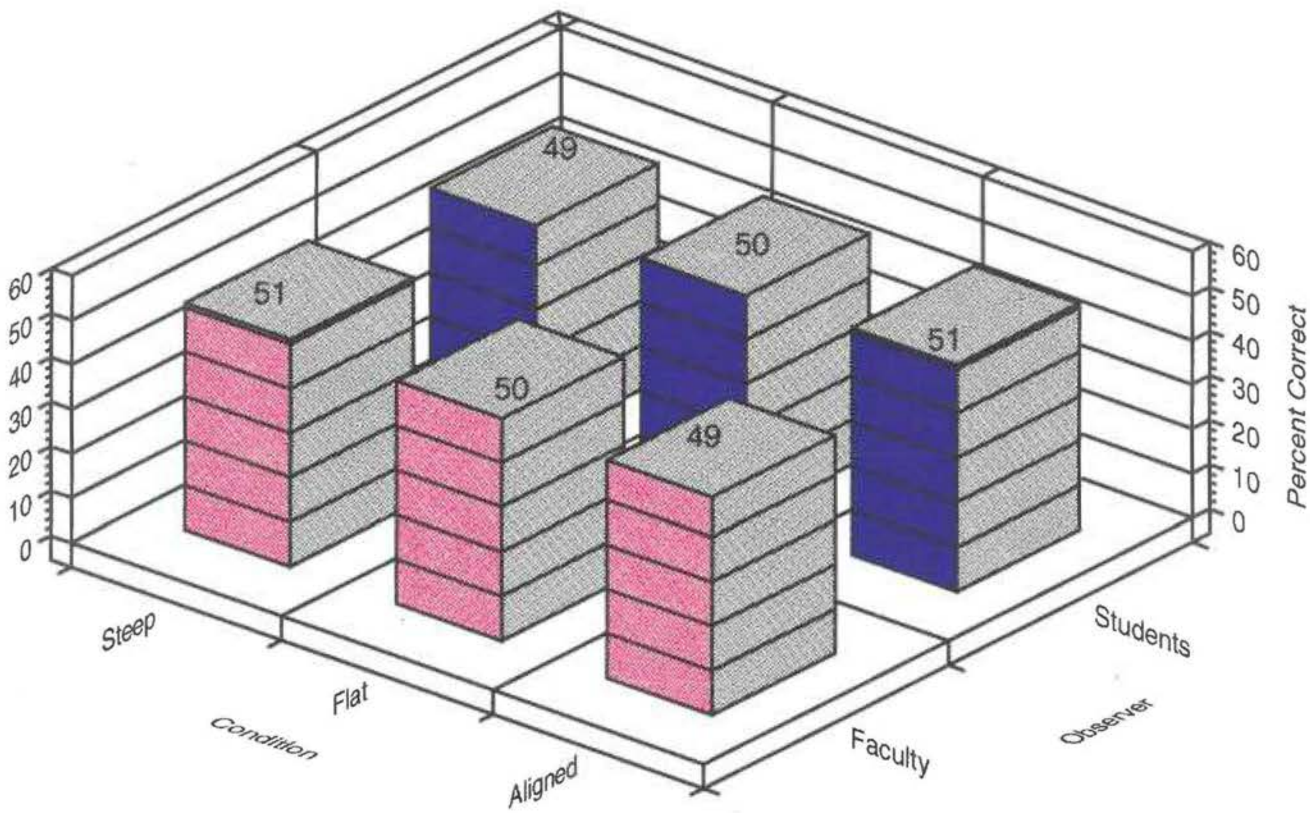
7.74@18
7.76 @108
ONK

7.74@18
7.76 @108
1.12D FTK

7.91 @10
7.78 @100
.50D FTK

Students vs. Faculty Rating Actual slides

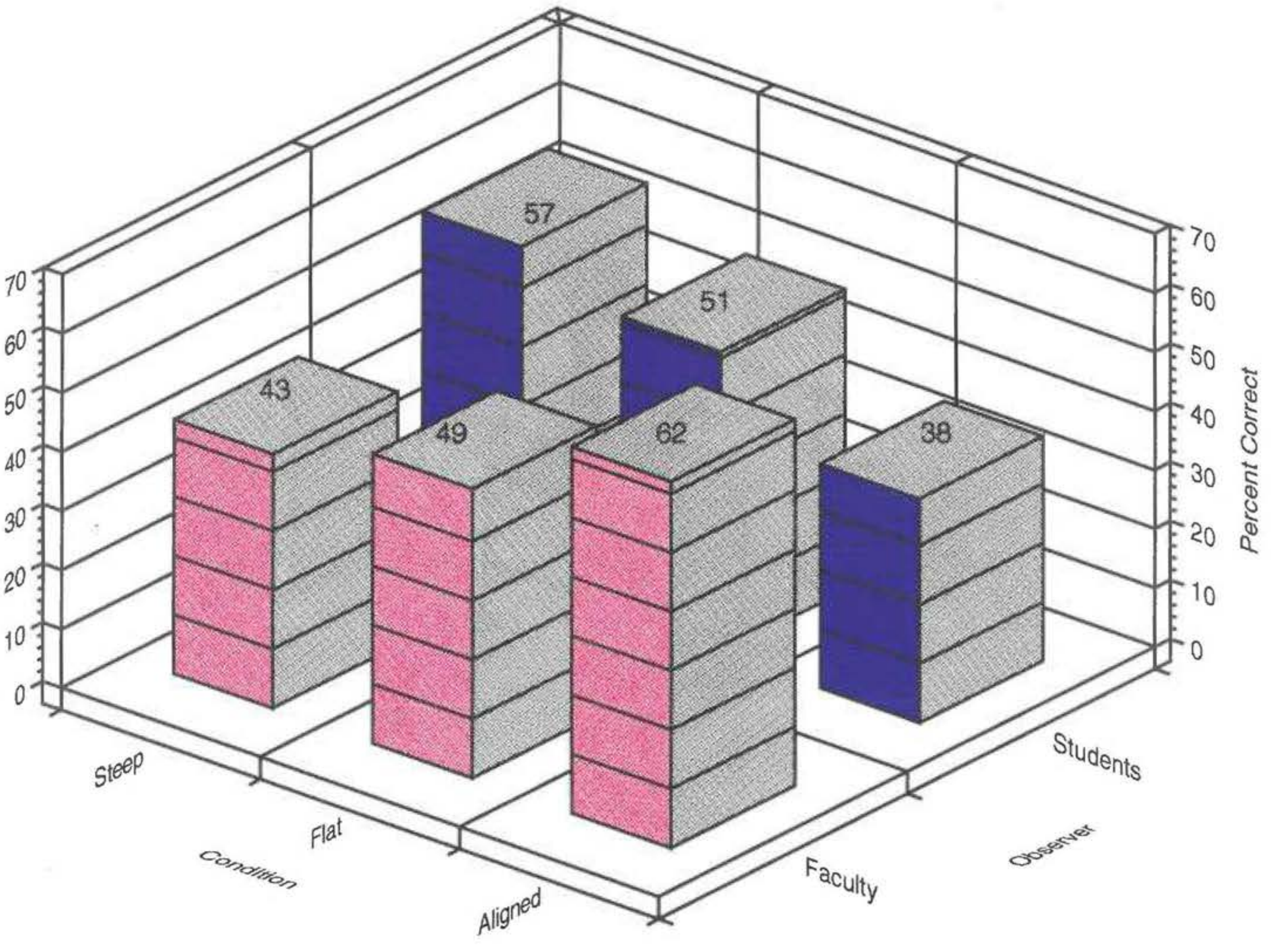
Figure 1



Chi Square = 0.024
DF = 2
P = 0.988

Students vs. Faculty Rating Simulations

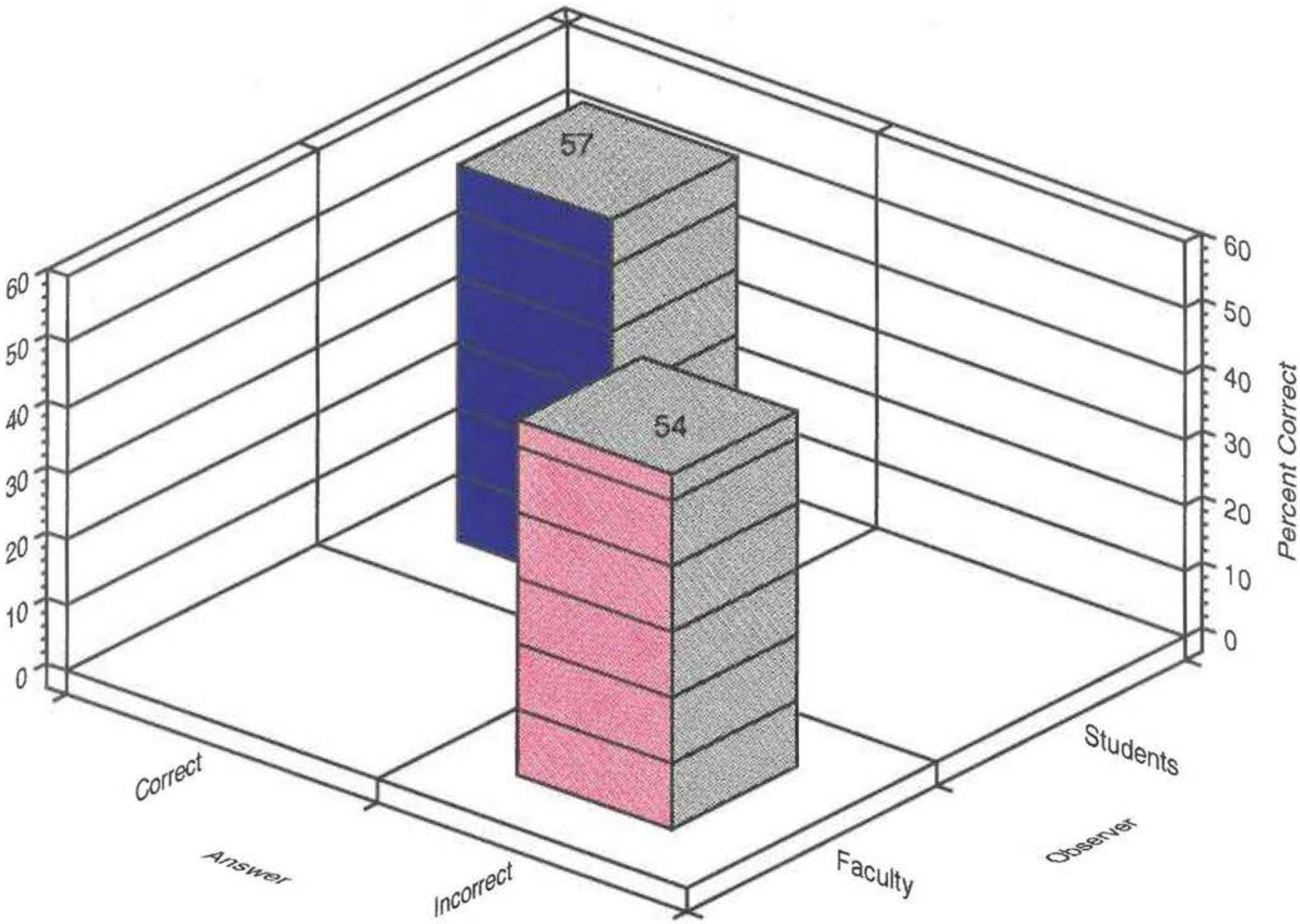
Figure 2



Chi Square = 4.614
DF = 2
P = 0.0996

Students vs. Faculty Matching Slides to Simulations

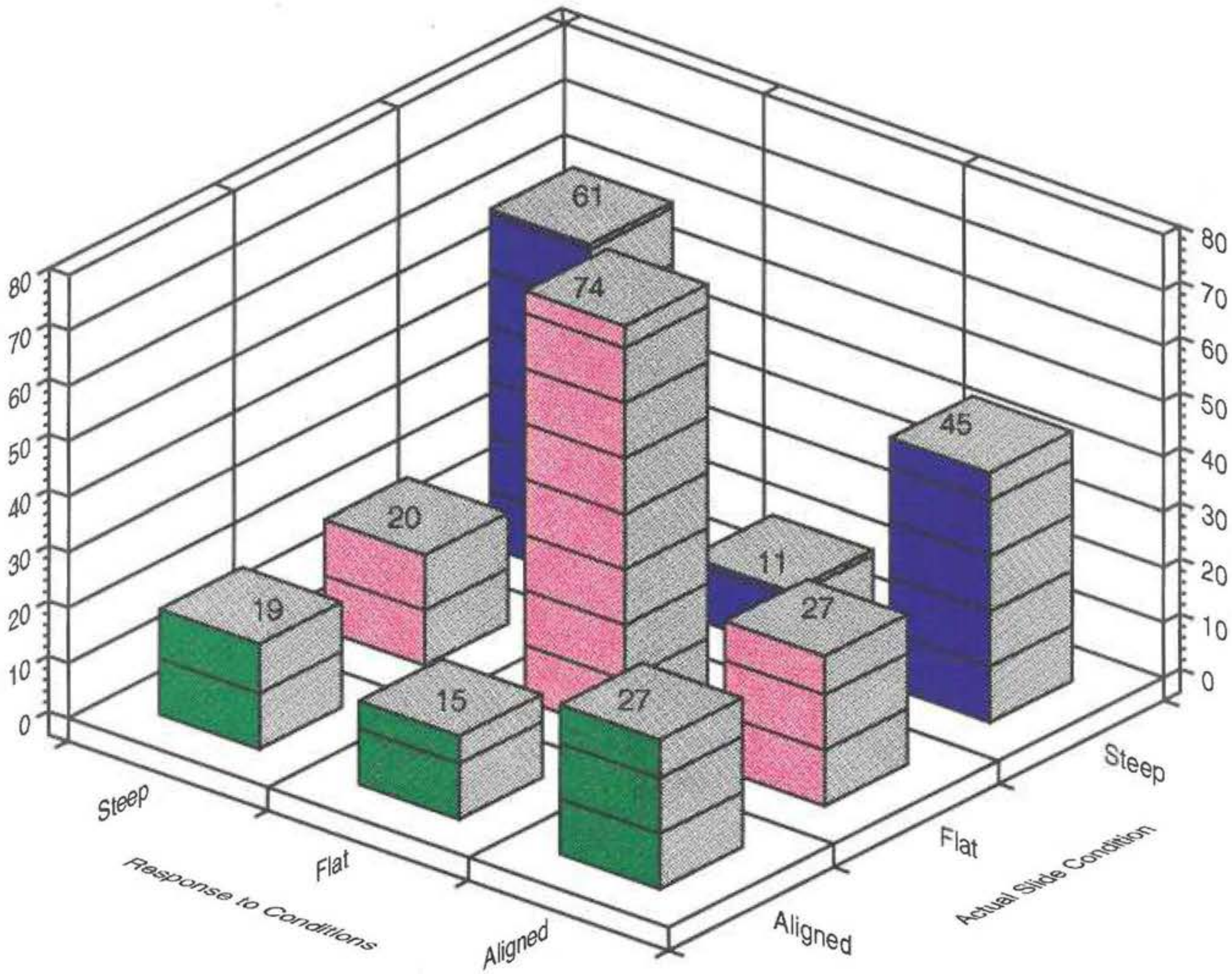
Figure 3



Chi Square = 2.525
DF = 1
P = 0.112

Predicted Slide Fits vs. Expected Fits

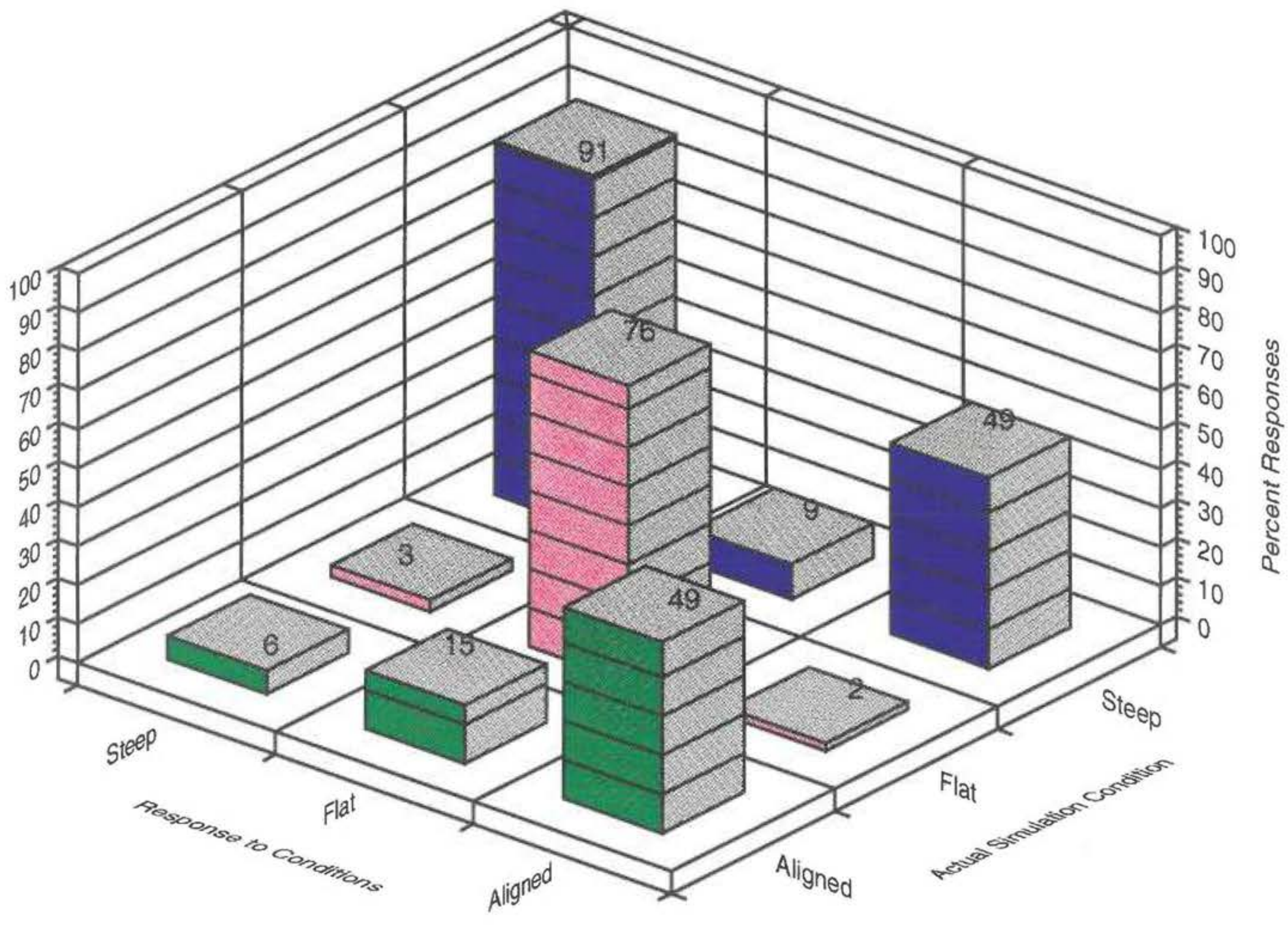
Figure 4



Chi Square = 68.164
DF = 4
P = 0.0001

Predicted Simulation Fits vs. Expected Fits

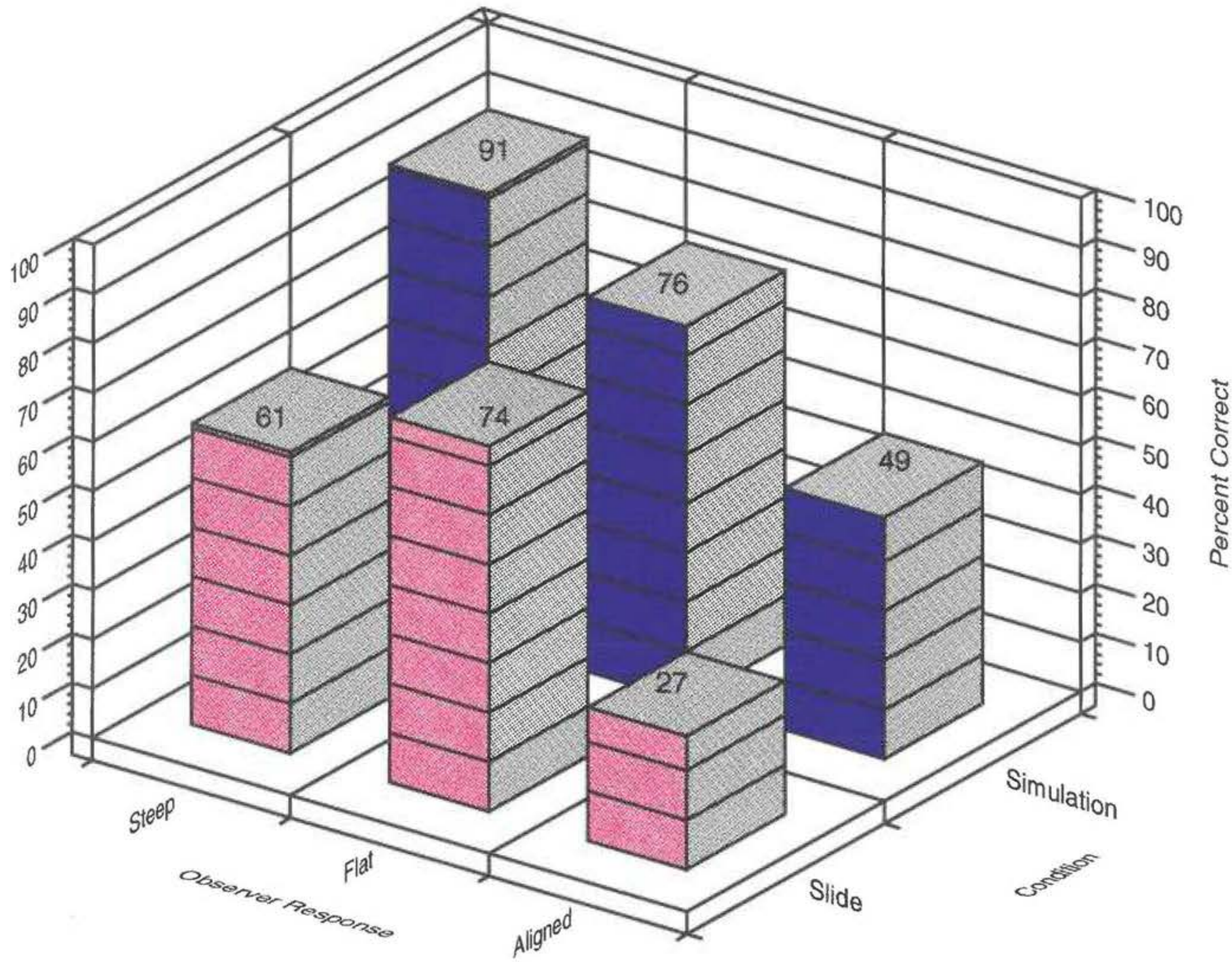
Figure 5



Chi Square = 193.913
DF = 4
P = 0.0001

Observer Accuracy of Predicting Simulations vs. Slides

Figure 6



Chi square = 4.598
DF = 2
p = 0.1003

Results

Figure(1) illustrates the relation between students and faculty in rating actual slides as steep, flat or aligned with an alpha level of 5% ($p = .05$) in a chi - square statistical review. No significant difference was seen between these two groups ($p = 0.988$).
Figure (2) represents similar circumstances with the exception of substituting the computer simulations for slide presentations. This again revealed no statistical difference between the two groups at an alpha of 5%($p = 0.0996$).
Statistical data also indicated there was no significant difference ($p = 0.112$) between the students and faculty members ability to correctly match each of the patients slide presentations to the corresponding simulations. This is shown in figure (3). Because these three areas previously graphed showed no significant difference between student and faculty members, the remainder of the testing lumped the observers into one group.
Based on the chi-square distribution in figure (4) the determination of steep, flat, or aligned fits of given slides, compared to that of their actual fit, revealed a statistical significance of $p = 0.0001$. Greater than 50% of the steep fits were seen as steep and nearly 75% of the flat fits were seen as flat. Only 27% of the aligned fits were accurately predicted.
The difference was also significant ($p = 0.0001$) between the observers ability to rate the simulations to their actual fit. This is shown in figure (5). Over 90% of the steep simulations were predicted correct and greater than 75% of the flat fits were correct. Nearly 50% of the aligned fits were estimated accurately.
Figure (6) reflects the observers accuracy in judging slides verses that of the simulations. There was no significant difference ($p = 0.10$) between these groups. At the alpha level of 10%, the simulations would be more accurately predicted than the slides.

Discussion

Overall, the simulations were easier and more accurately predicted than the slides. Although not statistically significant at the 5% alpha level the comparison between the slides and simulations at the 10% alpha level gave a significance in favor of the simulation.
The Flurowpredicter program was used with an 8 bit color monitor to create the simulations. This was much less than optimal. A 16 or 32 bit color monitor would present a smoother, less obvious gradient, giving the simulation a more realistic appearance . This improvement of simulation appearance might help to increase accuracy in correctly predicting the simulations. This in turn would make the overall difference between judging the slides and judging the simulations more significant, thus resulting in greater usefulness of the Fluropredicter program.
The results from this study were quantified by presenting the data in a static state. Because contact lens fitting is dynamic, difficulties arise. Faculty members, more so than students, mentioned the need for a blink to accurately evaluate the contact lens fits presented to them. Basing their judgments solely

on fluorescein patterns proved very difficult. The factors of lid tension, position, true lens centration, tear quality and amount of fluorescein were all void in these comparisons, which by an experienced observer, would be taken into account for the prediction of a fit.

Be it art form or just a difficult procedure to master, fluorescein evaluations for RGP fitting is in need of a more scientific approach in its learning process. The Fluropridicter program is one such method that will aid students and practitioners alike.

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